Geothermal Heating and Cooling in Australia

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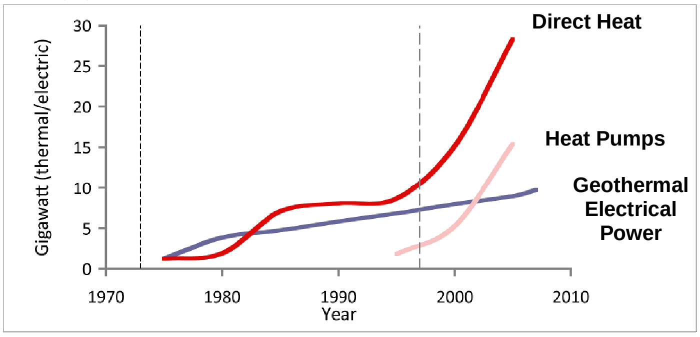
We outline the Australian potential for direct geothermal heat use which presently lags international use. Direct Use applications include Geothermal Heat Pumps (GHPs), Circulating Hot Water (CHW) and Sorption chillers for heating, cooling and drying. Direct heat use can substantially contribute to Australia's 2020 Mandatory Renewable Energy Target: GHPs can save 11.1 Mt CO_2-e/yr (1.9% of the total CO_2 released); sorption chillers, 31.4Mt CO_2-e/yr (5.5% of the total CO_2 released).

Direct Heat: An overlooked opportunity in Australia

Worldwide trends for direct geothermal heat use show an accelerating growth spurred initially by the oil crisis in 1973 and by the introduction of the Kyoto Protocol in 1998. The graph on the right shows the total worldwide geothermal electricity production in GW_e (electric) compared to the total thermal power in GW_t (thermal) by direct heat use including geothermal heat pumps (GHPs). Note that electrical power is more valuable than thermal power: 1 GW_e has a cooling capacity of 7 GW_t if used for driving an industrial electrical centrifugal chiller. *This is described by a **Coefficient of Performance (COP)** of 7, meaning 1 unit of electricity creates 7 units of heat*.

Over 1.5 Million GHPs are installed worldwide and Australia lags behind with only a couple of hundred units installed so far. This document summarizes the potential contribution of geothermally-driven air conditioning to fulfill the 2020 Renewable Energy Target (RET). In 2006, the HVAC & R industry consumed up to 45,000 GW hours of electricity, amounting to 22% of the country's production. The industry was also responsible for 7% of the national total of carbon emissions [1, 2].

In this note we estimate a more conservative reduction potential of 2%-6% CO_2 through Heating and Cooling by using geothermal sources in Australia.

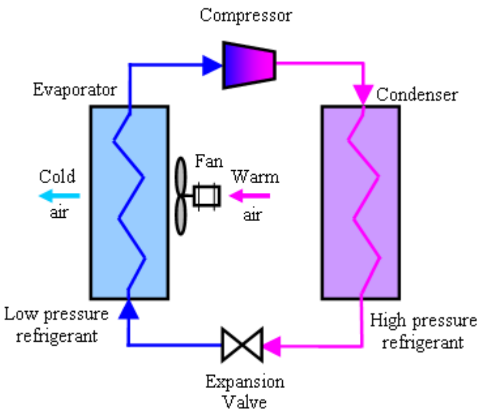


CO_2 savings Heat Pumps and Sorption Chillers

GHPs use the Earth rather than ambient air as a heat source and sink. Ground temperatures are cooler than the ambient air in the summer and warmer during winter, so GHPs benefit from pumping heat over smaller temperature differences—and therefore more efficiently—year round. They rely on nothing more than the classical principles of an electrically driven refrigerator/air conditioner. CO_2 reductions arise from COP improvements. This technology can be used in every household achieving an average COP of 4 compared to a COP of 3 for the average air conditioning. The improvements are thus estimated to be 25%.

A sorption chiller is a geothermal heat driven device which uses the same physical principles as a GHP but replaces the electrically driven compressor by a chemical heat driven device. Having dispensed with the need of a compressor a sorption chiller achieves a very high COP. An upper bound for the electrical energy consumed can be calculated from the electrical power used for the geothermal pump, the electrical power used in the sorption chiller itself and the fans for the air cooler or cooling tower and the air handling units in the sprawling complexes. Considering all these factors the COP is on the order of 20. The improvements are in the range of 80% CO_2 savings.

The geothermal sorption technology is new and will soon be tested for large scale industrial and commercial style applications for which the economics is currently more favorable.



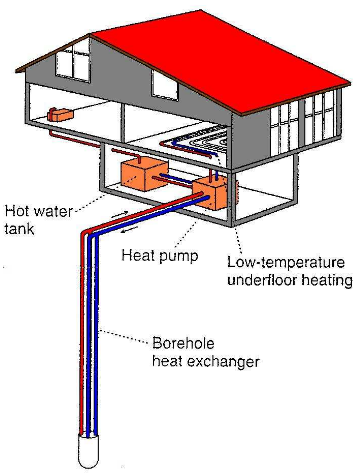
Heat Pumps use the same simple physics as classical refrigerators.

The underlying principle

GHPs and sorption chillers use the same simple physics as classical refrigerators. The technology was improved by Einstein who held about 17 patents in this field.

The principle of a heat pump relies on a cold bath and a hot bath. Heat is rejected to the hot bath via the work in the compressor. Having rejected the heat to the hot bath the fluid exits via an expansion valve where it cools and depressurizes through expansion. The heat pump can be used for both heating and cooling (case shown in the diagram).

The principle of a sorption chiller relies on the same scheme as the heat pump, i.e. the compression and expansion of a working fluid. In effect the sorption chiller is a unidirectional heat pump which is either designed for heating or for cooling but so far not for both applications in one single technological apparatus. The major difference between a sorption chiller and a heat pump is that the compressor is replaced by a heat driven chemical process assisted with a liquid pump. By replacing the mechanical compression with a thermal compression sorption chillers only have electrical requirement of 1-2% of their thermal output.



CO_2 Reduction Potential by Heat Pumps for Australia

We wish to give a conservative estimate of the CO_2 reduction potential for Australia.

The United Nations Training Program releases global CO_2 reduction estimates that are 3 x higher than our estimates. The UN report estimates that a global average of 0.5% CO_2 are already saved by ground source heat pump technology [3].

In Australia we have both heating and cooling requirements and we use efficient air conditioning units. We assume a 60:40 mix for cooling versus heating over a year. In order to avoid "double counting" we maintain that the electricity required to run heat pumps or sorption chillers, as well as to pump geothermal fluid and operate air handling units has to be included in the budget.

Using these figures, the total potential for CO_2 savings by geothermal heat pumps in Australia is:

11.1	**Mt CO_{2e}/year**
1.9%	**of total CO_2**

CO_2 Reduction Potential by Sorption Chillers for Australia

The same conservative estimate indicates a higher reduction potential for sorption chillers. However, heat pumps can be deployed readily while sorption chillers require achieving the economics of scale. At present we recommend a changeover at around 1 MW thermal capacity for heating or cooling. New implementations for large-scale industrial use are currently investigated and are not considered in this estimate.

The total potential savings of CO_2 by sorption chillers in Australia is:

31.4	**Mt CO_{2e}/year**
5.5%	**of total CO_2**

"The total worldwide CO_2 emission reduction potential of geothermal heat pumps has been estimated to be 1.2 billion tonnes/year." [1]

Further Direct Heat Use CO_2 reduction for Australia

Further direct heat use applications such as desalination, district heating, greenhouses, aquaculture, balneology, food, timber and industrial process drying, industrial processing are beyond the scope of this note. We wish to point out that these will significantly increase the direct heat use potential for Australia.

Neither the heat pumps nor the sorption chillers, nor geothermal energy are in themselves technological innovations. In fact, they are proven reliable technologies. As such they can help immediately to meet Australia's emission targets. Further direct heat use will multiply the reductions reported here.

[1] Fridleifsson, I.B., R. Bertani, E. Huenges, J. W. Lund, A. Ragnarsson, and L. Rybach 2008 postulate that "The possible role and contribution of geothermal energy to the mitigation of climate change. In: O. Hohmeyer and T. Trittin (Eds.)"

[2] "Cold Hard Facts: The Refrigeration and Air Conditioning Industry in Australia", Energy Strategies, DEWHA June 2007

[3] www.uniseo.org/heatpump.html.